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BULLETIN

OF THE

AMERICAN PHYSICAL SOCIETY

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PROGRAMME OF THE

PITTSBURGH MEETING

AT

MELLON INSTITUTE

PITTSBURGH

April 28–29, 1944

PUBLISHED BY THE AMERICAN PHYSICAL SOCIETY
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The American Physical Society

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AMERICAN PHYSICAL SOCIETY

PITTSBURGH MEETING, APRIL 28–29, 1944

THE **260th meeting of the American Physical Society** is to be held in the building of the Mellon Institute in Pittsburgh, Pennsylvania, on Friday and Saturday, April 28 and 29, 1944. The Physical Society of Pittsburgh is meeting jointly with us and has arranged the programme of Friday morning devoted to the physics of metals. Our new Division of Electron and Ion Optics (I. I. Rabi, *Chairman;* L. Marton, *Vice Chairman;* J. R. Pierce, *Secretary*) has assembled a group of papers in its field, which will be given on Saturday morning and afternoon. A symposium on cosmic rays will be held on Friday afternoon. Two groups of invited papers, including two on the philosophy of physics, are scheduled for Saturday. Contibuted ten-minute papers, other than those on the Division programme, will be given in four sessions on Friday and Saturday.

Hotels. The Local Committee recommends the Schenley and Webster Hall hotels in the vicinity of the Mellon Institute, and the William Penn and Roosevelt hotels in downtown Pittsburgh. Early reservation is requested and advised. The rates for the first-named two are $4 single, $6 double, $8.25 for a large room accommodating three, and $10 for two connecting rooms with a single bath. The rates for the William Penn are $3.85 and up single, $5.50 and up double; those for the Roosevelt are $2.75 and up single, $4.50 and up double. Visitors coming from the East and going to the Schenley or Webster Hall are advised to get off the train at East Liberty station and take streetcar 75 in the downtown direction. From the neighborhood of the Union Station and the downtown hotels, the streetcars to be taken to those hotels and to the Mellon Institute are 71, 73, 75, and 76.

The **registration-desk** will be in the lobby at the Bellefield avenue entrance of the Mellon Institute, which is the entrance to be used for access to all of the sessions.

The **dinner of the Society** will be held in the Hotel Schenley at 6:30 on Friday evening, at the price of $2.50 including tips. Tickets will be sold at the registration desk, and it is particularly requested that advance reservation be made on the form printed on the inside back cover page of this Bulletin.

The **luncheon for members and guests of Sigma Pi Sigma** will be held at the Webster Hall Hotel at 12:30 on Friday. Tickets at $1.25 may be bought at the registration-desk until ten A.M. on Friday, but it is requested that advance reservation be made by writing to the Executive Secretary of Sigma Pi Sigma, Professor Marsh W. White, State College, Pennsylvania.

The **Council of the American Physical Society** will meet at four on Friday afternoon in room 353 of the Mellon Institute, and again on Saturday evening in a place not yet chosen.

Prospective meetings of the Society. The Summer Meeting in the East will be held at Rochester, New York, on Friday and Saturday, June 23–24; it will include the inaugural meeting of the new Division of High Polymer Physics,

and will be held jointly with a meeting of the American Association of Physics Teachers. The Summer Meeting in the West will be held in Berkeley, California, on Saturday, July 22.

Prospective meetings of the Sections. The following announcements are transmitted by the Secretaries of the Sections, whose names and addresses are appended:

New England Section (Mildred Allen, Mount Holyoke College, South Hadley, Massachusetts). Simmons College, Boston, April 15.

Southeastern Section (E. S. Barr, Tulane University, New Orleans, Louisiana). Atlanta, May 5–6.

Ohio Section (Leon E. Smith, Denison University, Granville, Ohio). Ohio State University, Columbus, May 6.

General Rules Relating to Papers

By vote of the Society on December 27, 1940, no paper may be accepted for presentation at any meeting of the Society unless the title and an abstract of the paper are delivered to the office of the American Physical Society not later than the closing date stated in the printed call for the meeting.

The time allowed for the oral presentation of a contributed paper is ten minutes at most.

When two or more papers are contributed by the same member, all but one are placed on the "supplementary programme." (A paper by two or more members is credited to the one first named in its title.) For each paper on this programme the Secretary indicates a session at which it may be presented. The presiding officer at this session may call for it when the other papers are completed, may require that it be given in shortened form, or may read it by title.

Titles and abstracts of the papers to be presented are given in the following pages. Proofs of these abstracts have not been submitted to the authors. After submission of proof the abstracts will be published in an early number of *The Physical Review*.

Karl K. Darrow, *Secretary*,
American Physical Society,
Columbia University, New York 27, New York

PROGRAMME

FRIDAY MORNING AT 10:15

PROGRAMME ARRANGED BY THE PHYSICAL SOCIETY OF PITTSBURGH

Lecture Hall, Mellon Institute

Address of Welcome. SIGMUND HAMMER, *Gulf Research and Development Company.* (President, Physical Society of Pittsburgh.)

The Mechanism of Crystal Growth and its Consequences. WHEELER P. DAVEY, *The Pennsylvania State College.* (30 minutes.)

Modern Theories of Plasticity in Solids. FREDERICK SEITZ, *Carnegie Institute of Technology.* (30 minutes.)

Hipersil, the New Transformer Iron. T. D. YENSEN, *Westinghouse Research Laboratories.* (30 minutes.)

FRIDAY MORNING AT 10:30

Social Room, Mellon Institute

A1. The Small Gulf Gravimeter. ANTHONY CARNVALE, *Gulf Research & Development Company.*—For greater portability under difficult field conditions, a small and light modification of the Gulf Torsion Spring Gravimeter[1] has been constructed. The instrument consists essentially of a helical ribbon with a mass hanging freely at the lower end. Around the moving system are built the elaborate details needed to insure the necessary precision. These include the proper choice of spring material, temperature control, optical system, damping, magnetic shielding, and the elimination of air buoyancy errors. The salient features of the instrument and the extreme stability requirements of the moving system are discussed. In geophysical prospecting with a gravimeter, it is desirable to measure gravity differences from point to point to a precision of 10^{-7} g. The probable error of a single observation with the Gulf Gravimeter in routine field use is about 4×10^{-8} g. For stationary set-up (e.g., for measuring variations in tidal forces) the probable error is 1×10^{-8} g or better.

[1] R. D. Wyckoff, Geophys. 6, 13–33 (1941).

A2. A Thermopile for Micro-Calorimetry. L. S. MASON, *University of Pittsburgh.* (Introduced by A. G. Worthing.)—In the study of the thermodynamics of solutions it is desirable to measure heat effects (of the order of 0.001 cal.) which occur during the dilution of dilute solutions. In the Lange-type calorimeter[1] a thermopile of approximately 1000 junctions is used differentially. For this purpose a thermopile has been constructed using constantan-chromel-P couples[2] mounted in a sheet of Micarta, $5''\times10''\times\frac{1}{16}''$, and electrically insulated with a Vinylite resin which has an insulation resistance greater than 25 megohms. This instrument appears to offer somewhat better behavior than previously used units with respect to stability, sensitivity, and rapidity of response to temperature changes. The thermopile consists of two sections of equal numbers of junctions which are connected in parallel to a Leeds and Northrup HS galvanometer in series. At a scale distance of nine meters the sensitivity of the system is 0.25 microdegree per mm. Since one liter of diluent (water of dilute solution) is contained in each half of the calorimeter, this corresponds to a mean sensitivity of 2.5×10^{-4} cal./mm, with a probable error of the mean of ±0.03. The heat conductivity constant of the calorimeter is 0.004 min.$^{-1}$ and that of the thermopile is 0.03 min.$^{-1}$ Measurements with the present thermopile of the heats of dilution of sodium chloride solutions agree satisfactorily with well-established values.

[1] E. Lange and A. L. Robinson, Chem. Rev. 9, 89 (1931).
[2] H. F. Launer, Rev. Sci. Inst. 11, 98 (1940).

A3. Amplifier with Logarithmic Response. J. A. HIPPLE AND D. J. GROVE, *Westinghouse Research Laboratories.*—An amplifier with d.c. output voltage logarithmically proportional to the input signal over a range of three decades has been developed. This response characteristic is based on the charging and discharging of a condenser through a resistance and is thus independent of the characteristics of the individual tubes in the circuit. At any fixed setting the d.c. output is constant to better than 0.2 percent. The condenser discharge is initiated periodically by means of a trigger circuit which also synchronizes a saw-tooth oscillator with the exponential circuit. The d.c. level of this saw-tooth is varied by means of the input signal

so that a thyratron can be made to fire at any time from the beginning to the end of the interval. The impulse developed by the firing thyratron drives the grid of a hard vacuum tube from very negative to positive for an instant. The plate supply for this tube is the exponential voltage from the condenser-charging series resistance so that for the instant the grid is driven positive a signal appears across the load resistance equal to the voltage of the exponential at that instant. The output thus consists of a series of pulses of magnitude logarithmically proportional to the input voltage. These pulses are then averaged and filtered to d.c.

A4. Deflection of a Beam of Cesium Atoms by Gravity. I. ESTERMANN, O. C. SIMPSON, AND O. STERN, *Carnegie Institute of Technology.*—In the course of experiments for the exact measurement of the Bohr magneton[1] it was found necessary to determine the actual velocity distribution in a beam of cesium atoms 2 meters long with a cross section of 2 mm by 0.02 mm. In the apparatus used, this velocity distribution was measured by gravity deflection. The results showed that deviations from the Maxwell distribution in the range of low velocities occur at much lower oven pressures than expected.[2] The slow atoms remain longer in the neighborhood of the oven slit and have therefore a higher probability to be deflected from the beam by collisions. The results agree with an approximate calculation of this effect.

[1] O. Stern, Phys. Rev. 51, 852 (1937).
[2] Compare V. W. Cohen and A. Ellett, Phys. Rev. 52, 502 (1937).

A5. Performance Tests on the Penn State Type of G-M Circuits. HAROLD E. WALCHLI, *The Pennsylvania State College.*—Descriptions of the Penn State type of Geiger-Mueller circuits for the measurements of x-ray intensities were published in February, 1944 in *The Review of Scientific Instruments.* It is the purpose of the present paper to give the results of performance tests on such circuits. These tests are: 1. G-M high voltage supply, temperature effects, effects of changes in input voltage, effects of rheostat settings, improvements in circuits resulting from above tests. 2. Power and stabilized-bias supply, temperature effects, effect of load, voltage regulation, time constants. 3. Main amplifier, changes from original circuit, temperature effect, time constants. 4. Preamplifier, time constant, impedance, change in fixed bias, *vs.* plate current. 5. Auxilliary amplifier, temperature effects and improvements in the circuit intended to reduce heating effects. 6. Complete circuit, voltage recovery of G-M supply, oscillograph records of pulses through G-M counter.

A6. The Influence of Statistical Fluctuations on the Observed Size-Frequency Distribution of Bursts in a Single Ionization Chamber. L. G. LEWIS AND R. HAYDEN, *The University of Chicago.*—A particular burst of ionization occurring in an ionization chamber will be recorded as a burst larger or smaller than its true size by an amount equal to the statistical fluctuation in the non-burst particles occurring within the collecting time of the ions generated by that burst. This phenomenon causes the shape and absolute values of the observed size-frequency distribution curve to differ from the true curve by an amount given by:

$$f(a)=\int_0^\infty F(x)\exp\left[-b(x-a)^2\right]dx.$$

$f(a)$ is the observed differential size-frequency distribution function and $F(x)$ is the true function. The constant b is obtained from the conditions of observation in the ionization chamber. The true distribution $F(x)$ corresponding to the observed size-frequency distribution curve for a single chamber given by Lewis and Lewis[1] has been determined.

[1] L. G. Lewis and E. W. Lewis, Phys. Rev. 65, 63A (1944).

A7. The Ratio of the Average Current Generated by Cosmic-Ray Air Showers to the Total Current Observed in the Ionization Chamber. E. W. LEWIS AND L. G. LEWIS, *The University of Chicago.*—The average ionization current generated in a single unshielded ionization chamber by air showers producing bursts of more than 50 particles has been computed from the size-frequency distribution curve given by Lewis and Lewis[1] for an elevation of 10,650 ft. The average shower current was found to be 1.8×10^{-15} ampere. The current produced by all ionizing radiation in the chamber was 2×10^{-12} ampere. This value was obtained by measuring the voltage drop produced by the ionization current flowing through a 10^{12}-ohm resistor. The ratio of these currents is than 0.9 percent.

[1] L. G. Lewis and E. W. Lewis, Phys. Rev. 65, 63A (1944).

A8. Calculations on Extensive Cosmic-Ray Showers in Air. LINCOLN WOLFENSTEIN, *University of Chicago.* (Introduced by M. Schein.)—Large cosmic-ray showers in air, investigated with ionization chambers and coincidence counters, have been explained hitherto as originating from primary electrons of very high energy. The recent measurements by Lewis[1] of the frequency of coincident bursts in two unshielded ionization chambers provide a more complete picture of these showers. The theoretical coincidence frequency as a function of the particle density and the separation of the chambers has been calculated using the cascade theory of showers and the theory of the lateral spread of showers.[2] The calculations give much smaller values than the experiments for (1) the absolute value of all the frequencies observed, (2) the drop in frequency as the chambers are separated, and (3) the increase in frequency with elevation of bursts in a single chamber. These discrepancies strongly indicate that the bursts observed in the experiments are not due to showers from primary electrons. It is considered possible that the bursts may be explained by showers originating not at the top of the atmosphere, but relatively close to the chamber.

[1] L. Lewis, Phys. Rev. 65, 63A (1944).
[2] J. Roberg, Phys. Rev. 61, 735A (1942); 62, 304A (1942).

A9. Theory of Counter Experiments on Collision Electrons Ejected in Air by Mesotrons. ANATOLE ROGOZINSKI, *University of Chicago.*—It was found in recent counter-tube experiments[1] that mesotrons are associated with particles present at several meters distance from the mesotron

trajectories. These particles together with the mesotron possibly belong to an Auger-shower, but at least part of them are collision electrons (CE) ejected by the mesotron along its path in the air. The results of a theoretical calculation show that: (a) Only mesotrons of momenta $p > p_0 \sim 5\times10^8$ ev/c can eject in air CE sufficiently energetic to reach and to traverse a counter C placed at a distance D (a few meters) from the mesotron trajectory. (b) The number ν of CE, which arise from a single mesotron and which are able to discharge (C), is practically independent of the mesotron momentum p, if the spin dependent term is neglected, and is given, in first approximation, by $\nu_0 = (BS/\pi D)\times\Theta_{max}(D, E_1)$, where: $B = 10^{-2}$ for standard air, S = effective area of (C) in m², D is expressed in meters, and E_1 = minimum energy necessary for an electron to traverse the counter wall; for $E_1 = 2$ Mev, e.g., the function Θ_{max} decreases from 0.50 for $D = 2$ m, to 0.30 for $D = 10$ m. (c) When the mesotron spin (0 or $\frac{1}{2}$) is taken into account, $\nu \leq \frac{1}{2}\nu_0$ for the lowest mesotron momenta, but approaches asymptotically ν_0 as p increases. (d) Shower production in air of the CE adds a very small contribution to the counting rate in (C).

[1] P. Auger and An. Rogozinski, Phys. Rev. 65, 64 (1944); An. Rogozinski, Phys. Rev., in print.

A10. Measurement of High Energy Electrons in A Showers. R. E. LAPP, *Ryerson Physical Laboratory, University of Chicago.*—A discussion is given of the energies associated with high energy particles (electrons and photons) present in the cores of A showers at sea level. The approximate values of these energies are obtained from an analysis of the number of cosmic-ray bursts found to be coincident with A showers as a function of the iron shielding the ionization chamber in which the bursts occur. The A showers are detected by lateral arrangements of G-M counter coincidence sets.

FRIDAY AFTERNOON AT 2:00

Lecture Hall, Mellon Institute

Symposium on Cosmic Rays

The Nature of Cosmic-Ray Phenomena. MARCEL SCHEIN, *University of Chicago.* (30 minutes.)

The Role of the Primary Cosmic Radiation. W. F. G. SWANN, *Bartol Research Foundation.* (40 minutes.)

On the Lateral Spread of Cosmic-Ray Showers. L. W. NORDHEIM, *Duke University.* (20 minutes.)

Nuclear Disintegrations Produced by Cosmic Radiation. M. GOLDHABER, *University of Illinois.* (20 minutes.)

Production of Neutrons by Cosmic Radiation. S. A. KORFF, *New York University.* (20 minutes.)

FRIDAY AFTERNOON AT 2:30

Social Room, Mellon Institute

B1. The Mechanics of the Metal Cutting Process. I. Simple Straight-Edged Tool and Continuous Chip. M. EUGENE MERCHANT, *Cincinnati Milling Machine Company.*—The analysis of the mechanics of a simple straight-edged cutting tool removing a continuous chip in the absence of a built-up edge, and traveling in a direction perpendicular to the cutting edge, as introduced by Ernst and Merchant,[1] has been expanded and correlated with experiment. In this special case, the chip is formed by a process of shear in a direction perpendicular to the cutting edge, in a plane extending from the cutting edge to the work surface, and the resultant force on the tool or on the work is coplanar with all its significant components and with the direction of relative motion of tool and work. Relationships pertinent to the geometry of chip formation are derived. Significant relationships are derived between the various force components and such quantities as the shear strength of the metal, the coefficient of friction between chip and cutting tool, and the work done in shearing the metal and in overcoming friction on the tool face. Relationships are presented showing how the direction of shear of the metal ahead of the cutting edge is determined by the geometry of the force system, for certain special cases.

[1] H. Ernst and M. E. Merchant, *Surface Treatment of Metals* (American Society for Metals, 1941), pp. 299–378.

B2. Anomalous Behavior of the Electrical Resistivity of Some Iron-Cobalt Alloys. SIDNEY SIEGEL AND ROBERT MCGREARY, *Westinghouse Research Laboratories.*—In the course of the development of iron-cobalt alloys for magnetic purposes, erratic variations in the resistivity of alloys of presumably similar composition and thermal history had been observed. Systematic attempts to determine the cause of these variations were made. The possibility of these being due to an order-disorder transition was investigated. The equilibrium electrical resistivity of alloys containing 42 percent Co, and 30 or 42 percent Co plus 2 percent V, was measured over the range 20°C to 1100°C. The resistance rises monotonically up to about 950°C, the phase change temperature, where a discontinuous increase occurs. Above this temperature, the resistivity again increases, with a smaller constant, temperature coefficient. No evidence for an ordered structure was found from these measurements. A series of experiments attempting to relate the room temperature resistivity of these alloys to thermal history showed that the cold-rolled alloy has a lower resistivity than the presumbably equilibrium value of the alloy slowly cooled from high temperatures; the alloy quenched from above the point has higher resistivity than the cold-worked alloy, but still is lower than the annealed material. Cold work following quenching reduces the resistivity again; repeated quenching and annealing result in cyclic decrease and increase in resistivity. These effects are only present in alloys containing V, and are absent in the 30 percent Co alloys. They are difficult to account for with any of the usual hypotheses concerning the resistivity of alloys.

B3. Magnetic Permeability at Very Rapid Rates of Change of Induction. H. L. GLICK AND SIDNEY SIEGEL, *Westinghouse Research Laboratories.*—The permeability of several magnetic materials in the form of strip 0.003 inch thick or less was measured at rates of change of induction as high as 10^{10} gauss/sec. The measurements were made from cathode-ray oscilloscope observations of B and H, a square pulse of voltage about one microsecond in duration being applied to coils surrounding the sample. During this pulse, the induction rises linearly. The eddy current effects present in such a situation have been calculated by T. D. Holstein and the B-H loops observed are in qualitative agreement with those predicted with these calculations from the d.c. magnetic properties, the electrical resistivity, and the thickness of the strip material. Quantitatively, however, the observed loops indicate a permeability, during the rise of induction, about 30 to 50 percent lower than the d.c. permeability. This indicates that the mechanism of the magnetization process, at rates of change of induction so great that the average velocity of domain boundary movement must be of the order of 10^5 cm/sec., is appreciably different from that obtaining in slow field changes.

B4. Curie Transition in Ferromagnetic Alloys and Glass Containing Nickel. W. R. HAM AND HOWARD S. COLEMEN, *The Pennsylvania State College.*—The experimental results obtained by Bennett and Ham in their studies of hydrogen diffusion through ferromagnetic binary alloys showed breaks not only associated with a Curie transition for a particular alloy, but also Curie transitions corresponding to the metals from which the alloy was made. It has been suggested that such Curie transitions corresponding to the components of the alloy were caused by segregation. Magnetic experiments have been performed on the same alloys used by Bennett and Ham and the positions of the Curie transitions reported by them have been confirmed; however, it was found that the intensity of the Curie transitions corresponding to the components of the alloy were several orders of magnitude less than the Curie of the alloy itself. Further experimental work involving magnetic torsional measurements of glasses containing various amounts of nickel-oxide show a persistence of Curie transition at 360°C, even though the nickel-oxide content was less than one percent. This latter fact again suggests that the Curie transition in some cases is not altered by a chemical combination of ferromagnetic elements with certain other elements, since it is rather unlikely that there would be any appreciable segregation of nickel in a glass having a low nickel content. Although the experimental work to date does not justify saying there could be no segregation in the cases cited, it is felt that the evidence is against segregation as an explanation of the results.

B5. Crystal Structure of Tellurium. JOHN D. ORNDOFF, *Purdue University.*—Results of Hall effect, thermoelectric power, and resistivity measurements on tellurium have been interpreted as evidence[1-3] that tellurium exists in two crystalline modifications, present in various proportions depending on the temperature and the heat treatment of the sample. To decide whether these anomalies in electrical behavior as a function of temperature are really due to the development of various modifications, the crystal structure of tellurium as a function of temperature has been investigated. X-ray diffraction pictures taken with Seeman-Bohlin[4] and Debye-Scherrer cameras at temperatures from −192°C to 160°C fail to show any evidence of two modifications, nor do they show any peculiar change in lattice parameters with temperature. Tellurium evaporated in vacuum upon a glass plate produces two types of deposits: in contact with the glass a thin homogeneous metallic layer of tellurium, on the outside a second film finely dispersed, black and sooty. X-ray investigations of both layers give the ordinary tellurium pattern. Electron diffraction patterns[5] show complete but diffuse electron diffraction rings for the metallic film, while the tellurium black[4] yields a very sharp orientation pattern. This orientation and the non-symmetry of the pattern can be explained as due to the fact that the crystals did not have random distribution about the orientation axis but tended toward an alignment in a preferred direction.

[1] Haken, Ann. d. Physik **32**, 291 (1910).
[2] Smith, Phys. Rev. **1**, 352 (1913).
[3] Wold, Phys. Rev. **7**, 169 (1916).
[4] Lark-Horovitz, Science **64**, 303 (1926).
[5] We are indebted to Mr. T. S. Renzema for taking the electron diffraction pictures.

B6. Spontaneous Time-Dependent Changes in Crystalline Material. D. D'EUSTACHIO AND SELMA BLAZER BRODY, *Brooklyn Polytechnic Institute.*—Freshly broken crystalline material undergoes a change during the first few hours after being prepared. The phenomenon may be described tentatively as a further breaking up of freshly broken material. In one experiment particles of adularia (orthoclase) between 200 and 300 mesh in size were photographed a few minutes after preparation with a focusing camera using unfiltered copper radiation. After an interval of several hours, during which the sample was not disturbed, another photograph was taken. A marked increase in the number of spots was observed. The original spots were still present. The experiment has been tried with other materials. There is good reason to believe that the change is associated with the surface rather than the interior of the material.

B7. Operating Characteristics of Ceramic Dielectrics with Dielectric Constants in Excess of 1000. R. B. GRAY, *Erie Resistor Corporation.*—Within the past several years there have been introduced ceramic condensers which have extremely high dielectric constants. These materials are somewhat similar in their properties to Rochelle salt. However, their high dielectric constant obtains over much wider temperature and frequency ranges. There are quite a great many possible combinations, and curves showing some of the temperature and frequency variations are presented. Materials are subject to certain aging and voltage effects which produce deviations from the nominal capacity. The temperature variation of capacity usually exhibits a peak which may be explained by referring to the thermal expansion curve of the material. More exact explanation in terms of composition and crystal structure must be deferred until a later date when conditions will permit such discussion. Materials are somewhat affected by humidity and at least a certain fraction of them is water soluble so that the production of commercial condensers requires fairly stringent waterproofing methods. Probably the greatest difficulty with these materials is the fact that they are subject to ionic conduction if certain trace impurities are present. This results in failure on life test, particularly at slightly elevated temperatures. Data showing the effects of several impurities will be presented.

B8. A Resonant Cavity Method for Measuring Dielectric Properties at Ultra-High Frequencies (50–1000 Megacycles). C. N. WORKS, T. W. DAKIN, AND F. W. BOGGS, *Westinghouse Research Laboratories.*—A re-entrant cylindrical cavity has been adapted to measure the dielectric constant and power factor of small disk samples of insulating materials. The disk of dielectric is placed between the flat ends of the cylindrical posts which form the re-entrant part of the cavity. The circuit is analogous to a less than $\frac{1}{4}$-wave-length section of air-filled coaxial transmission line shorted at one end and ending in a capacitor with dielectric at the other end. This cavity with the dielectric inserted is brought to resonance by tuning the frequency of a loosely coupled oscillator. The power factor of the dielectric is determined from the breadth of the resonance curve and the dielectric constant is obtained by removing the disk of dielectric and decreasing by a measured amount the separation of the flat ends of the re-entrant posts until resonance is again obtained at the same frequency as previously. The precision differential screw for varying the extension of the re-entrant post and other mechanical details are described. Electrical coupling and detecting methods are also discussed as well as the theory of the measurements. Each individual cavity can be utilized only over a frequency range of about 1.5 ratio from lowest to highest frequency. Therefore, several different sized cavities would be required to cover a range of frequency from 50 to 1000 megacycles. An accuracy of ± 0.00005 in tan δ and ± 1 percent in dielectric constant may be obtained in routine measurements. Because the cavity has a very high Q (>2000), it is much more sensitive to low power factor dielectric samples than any conventional coil and capacitor resonant circuit. Operation of the apparatus is simple and rapid and very similar to the susceptance variation technique now used at lower radio frequencies.

B9. Decomposition of Water with the Permanent Magnet. F. EHRENHAFT, *New York City*—Permanent Alnico magnets are used. They are semicircular rings with outer radius of 5.1 cm and inner radius of 1.58 cm, 1.75 cm thick. These were fitted with pole pieces of soft Swedish iron having circular cylindrical extensions 1 cm in diameter, 12.5 mm long, terminating in a truncated cone 6 mm in diameter. The extensions passed through rubber gaskets into a glass cell divided by a partition so that the gas evolved from either pole could be collected separately. The pole faces were 3 mm apart. The field strength was much less than that in the earlier described experiments with the electromagnet.* Using 4 percent H_2SO_4 in the cell, oxygen was found to be coming from both poles together with the hydrogen formed by chemical action. More oxygen was found to be coming from the north pole than from the south. For instance, 1.43 percent and 1.12 percent in one experiment, 0.87 percent and 0.57 percent in another. Using the pole pieces alone without applying the magnet, 0.00 percent oxygen was found. Measuring the pole strength of one magnet by means of a search coil and ballistic galvanometer before and after one magnetolysis, the decrease in strength was from 16,980 to 15,380 maxwells. The flux value of this magnet was at a steady state before and after this test. The evidence here given shows that water can be decomposed by a permanent magnet as well as by the electromagnet, that magnetism is polar, and that the energy for this process is supplied by the magnet as shown by its loss in pole strength.

* Felix Ehrenhaft, Phys. Rev. **60**, 169 (1941); **61**, 733 (1942); **63**, 216, 461 (1943); **64**, 43 (1943), etc.

FRIDAY EVENING AT 6:30

Hotel Schenley

Dinner of The American Physical Society

SATURDAY MORNING AT 10:00

Lecture Hall, Mellon Institute

Inaugural Programme of the Division of Electron and Ion Optics

Address of Welcome by the Chairman or the Vice Chairman of the Division

Historical Background of Electron Optics. C. J. CALBICK, *Bell Telephone Laboratories.* (30 minutes.)

The Electron Microscope in Metallurgical Research. C. S. BARRETT, *Carnegie Institute of Technology.* (20 minutes.)

Extending Microscopic Examination of Metals. F. KELLER AND A. H. GEISLER, *Aluminum Company of America.* (20 minutes.)

The Magnetically Focused Radial Beam Vacuum Tube. A. M. SKELLETT, *Bell Telephone Laboratories.* (20 minutes.)

Kinematics of Reflection Oscillators. A. E. HARRISON, *Sperry Gyroscope Company.* (20 minutes.)

Business Meeting of the Division

SATURDAY MORNING AT 10:00

Social Room, Mellon Institute

C1. Magnetic Potential Energy and the Zeeman Effect. F. W. WARBURTON, *University of Kentucky.*—The quantization of orbital angular momentum in units of $h/2\pi$ remains unchanged in obtaining the Schroedinger equation from the Hamiltonian function which includes magnetic potential energy. When intrinsic electron spin is omitted and the magnetic potential energy of an orbit used instead, the vector model description of the Zeeman effect needs revision. Bohr's original assumption that the magnetic field affects the mechanism of transitions between energy levels, together with the mutual electrostatic oscillating dipole force of neighboring atoms during a transition, provides a qualitative explanation of certain anomalous Zeeman patterns, and it avoids the incongruity of including classical magnetic force in setting up the energy states then suspending this force during a transition between states.

C2. Sensitized Fluorescence of Copper and Test of Selection Rule for Collisions of the Second Kind. F. K. MCGOWAN AND J. G. WINANS, *University of Wisconsin.*—Sensitized fluorescence and Tesla discharge spectra of copper vapor were obtained with the simplified procedure used for other elements.[1] Particles of copper were heated to 1377° without collapsing the fused quartz tube. The Tesla discharge spectrum showed 28 copper lines and the sensitized fluorescence showed four. These were the resonance doublet 3273 and 3247 and lines at 2492 and 2441. Microphotometer comparison of intensities of lines in sensitized fluorescence and arc showed 2492 greatly enhanced in fluorescence. The selection rule[2] found for collisions of the second kind for Sn and Pb was found to apply to copper excited by collision with Hg $^3P_0$. The rule states that for atoms A and B colliding $J=J_A+J_B$ remains constant during collisions of the second kind. This rule requires Cu 3273 to be stronger than 3247 for excitation by Hg $^3P_0$. 3247 is stronger than 3273 in the arc spectrum. Fluorescence excitation by Hg $6\,^3P_0$ alone was produced by introducing a time lag of about 10^{-4} sec. between excitation and emission.

[1] J. G. Winans and R. M. Williams, Phys. Rev. **52**, 930 (1937).
[2] J. G. Winans, Phys. Rev. **60**, 169A (1941).

C3. Raman Spectra of Normal-heptane and Normal-hexane. FORREST F. CLEVELAND AND DONALD E. LEE, *Illinois Institute of Technology.*—Continuing work on hydrocarbons, Raman frequencies, relative intensities, and depolarization factors have been obtained for *n*-heptane and *n*-hexane. The relative intensities and depolarization factors were obtained by use of a Gaertner microdensitometer. The Raman frequencies will be compared with the previous results of Kohlrausch and Köppl and of Rosenbaum, Grosse, and Jacobson. No previous polarization data seem to exist and the previous relative intensities are only visual estimates. The results will be discussed in the light of the selection rules for various possible equilibrium configurations. For example, if *n*-hexane has a symmetry corresponding to the point group C_i, 27 of the 54 fundamentals are forbidden in the Raman spectrum and all of the allowed Raman fundamentals should be polarized. Furthermore, for this symmetry, combination frequencies of two A_g or two A_u frequencies, overtones of A_g frequencies, and first, third, fifth, etc. overtones of A_u frequencies, are all allowed in the Raman spectrum and could bring about Fermi resonance interactions if they should fall sufficiently close to one of the type A_g Raman lines.

C4. Some Double-Bond Absorptions in the Vacuum Ultraviolet. JOHN R. PLATT, *Northwestern University.*—Recent measurements in heptane solution[1] are compared with the theoretical predictions of Mulliken[2] and McMurry[3] on the absorption below 2000A of conjugated and unconjugated C=C and C=O groups, with very satisfactory agreement. The data shed light on the theory of −COOR: the first true maximum above $N \rightarrow Q$ (54,000 cm^{-1}) must be above 66,000 cm^{-1} (by extrapolation) with $f > 0.1$, and so is probably the $N \rightarrow V$ transition. The splitting and red shift of the 1850A ethylenic peak with increasing number of double bonds (unconjugated) may be attributable to hyperconjugation (f values increasing almost linearly, as predicted), but the reason for the red shift (about 1000 cm^{-1} of the *trans*-ethylenes from the *cis*-ethylenes is not clear. Secondary maxima near 55,000 cm^{-1} in the conjugated acids and dienes may be the $N \rightarrow V_{2,3}$ transition.

[1] Platt, Rusoff, and Klevens, J. Chem. Phys. 12, 535 (1943); Rusoff, Platt, Klevens and Burr, in preparation.
[2] Mulliken, Reports on Progress in Physics (Physical Society of London, 1941), Vol. VIII, p. 231.
[3] H. L. McMurry, J. Chem. Phys. 10, 655 (1942).

C5. Apparatus for the Determination of Dispersion at Supersonic Frequencies. L. N. LIEBERMANN, *University of Kansas.*—Variation of the velocity of sound with frequency yields useful information on the rate of transfer of translational energy to molecular vibrational energy. Variations have been measured by a method which allows the direct observation of small velocity changes. The apparatus permits comparison of the phases at various frequencies in two gases, one being a non-dispersive gas. If the phases are measured in the two gases at positions which correspond to equal numbers of wave-lengths from the source, then $\Delta\phi/\phi = \Delta V/V$ where $\Delta\phi$ is the phase difference in the two gases and V is the velocity in the dispersive gas. A 90-kilocycle quartz bar is excited at its fundamental and upper harmonics to produce the various frequencies. The sound is received by an L-cut Rochelle salt microphone and the phase determined by a 360° electrostatic phase shifter accurate to ±3°. ϕ was 3600° (10 wave-lengths) at the fundamental. V is taken from the literature. Five frequencies between 90 and 450 kilocycles were used; these differed by approximately 90 kilocycles. Insufficient amplifier gain at higher frequencies prevented extension of this range. Measurements on the dispersion of CO_2 at atmospheric pressure are in agreement with previous values.

C6. Precision Measurement of the Velocity of Sound at Supersonic Frequencies Using a Microphone. E. J. GROTH AND L. N. LIEBERMANN, *University of Kansas.*—The most precise measurements on the velocity of sound at supersonic frequencies have been made with the Pierce interferometer. The present method which is adapted from audible frequency technique offers greater precision together with certain advantages. The horizontal plates of a cathode-ray tube are connected to a radiofrequency oscillator which excites a quartz bar; the vertical plates are connected through a video amplifier to a microphone. The ellipse formed indicates wave-length as the microphone position is changed. The microphone is an L-cut Rochelle salt crystal. The microphone screw, 8 cm long, is calibrated to 0.001 mm. Frequencies are measured to 1 part in 10^5 using standard equipment. Measurements made on the velocity of sound in air (uncorrected for CO_2 and H_2O content) at 0°C indicate a value of 332.99±0.01 m/sec. at a frequency of 477.72 kilocycles/sec. Values at other frequencies are obtained by exciting the quartz at various harmonics. The apparatus can readily be adapted to measure sound absorption.

C7. The Kinetics of the Thin Oxide Film Formation of Iron and Copper. EARL A. GULBRANSEN, *Westinghouse Research Laboratories.* (Introduced by S. Siegel.)—The oxidation measurements are obtained by means of a sensitive vacuum microbalance. The temperature regions of 100 to 200°C for copper and 200 to 450°C for iron are covered. The pressure is varied from 0.2 to 0.0002 atmosphere of oxygen. Several types of empirical equations are shown to fit the data. The parabolic equation is found to fit after a certain initial period of the reaction. The form of the equation can be correlated with diffusion phenomenon. The influence of temperature pressure and surface effects are discussed.

C8. Mechanism of Electrolytic Oxidation of Aluminum. SCOTT ANDERSON, *Carleton College.*—When an aluminum sheet is made the anode in certain electrolytes, a layer of oxide forms on its surface and constitutes a barrier between the metal and the electrolyte. Further oxidation can occur only as a result of (1) the aluminum or (2) oxygen ions penetrating this film. A reaction mechanism is proposed in which one of three aluminum ions diffuses from the metal to the electrolyte and the other two occupy aluminum sites in an extension of the oxide lattice. The oxygen sites so

created are filled by ions from the oxide and the oxygen ion vacancies diffuse to the oxide-electrolyte interface. The mechanism is successful in explaining the strong adherence of the films, and in predicting the experimental ratio of the weight of oxide formed to the weight of metal removed, as well as other properties.

C9. A New Research Tool—Irreversible Solution Potential Measurements. R. H. BROWN AND R. B. MEARS, *Aluminum Research Laboratories.*—Reversible solution potential measurements are contrasted with irreversible solution potential measurements. The advantages and limitations of each are discussed. The importance of selecting suitable conditions, especially methods of surface preparation and composition of the solution used for making the measurements, is emphasized. It is pointed out that the limitations of the method are largely dependent on the type of solution used. The interpretation of results obtained using solutions producing relatively high anodic polarization is presented and compared to results from solutions causing relatively high cathodic polarization. Methods are given for applying irreversible solution potential measurements to studies of: (a) solid phase diffusion of metals, (b) solid phase metallurgical transformations, (c) distribution and mechanism of corrosion, (d) cathodic protection and galvanic action, (e) metallic and nonmetallic coatings. Each of the above is illustrated by specific examples. In most cases the results of solution potential measurements are correlated with results obtained by other methods.

[1] Chemical Metallurgy Division, Aluminum Research Laboratories.
[2] Chief, Chemical Metallurgy Division, Aluminum Research Laboratories.

Invited Papers

Potential Barriers to Internal Rotation in Organic Compounds. J. G. ASTON, *The Pennsylvanial State College.* (30 minutes.)

Photoelectric Measurement of Weak Emission Spectra. D. H. RANK. *The Pennsylvania State College.* (30 minutes.)

SATURDAY AFTERNOON AT 2:00

Social Room, Mellon Institute

Invited Papers

The Philosophical Foundations of Quantum Mechanics. HANS REICHENBACH, *University of California.* (45 minutes.)

Physics and Phenomenology. HENRY MARGENAU, *Yale University.* (30 minutes.)

Physics Bulletins for High School Bulletin Boards. (The Pennsylvania Conference of College Physics Teachers. Speaker to be announced.) (15 minutes.)

Contributed Papers

D1. Deviations in the Classification of Stable Nuclei. J. D. KURBATOV, *The Ohio State University.*—One case of deviation from the rule imposed in the classification is in even nuclei of period four, $I=20$. The mass number of the last nucleus of the group is higher than that of the first of the following group, $I=28$. This is due to $_{62}Sm^{144}$. The isobaric nucleus $_{60}Nd^{144}$ and the next in the sequence $_{62}Sm^{148}$ of P_8 are said to be radioactive. Other gaps in groups of even nuclei are found mainly in periods 6 and 8. The deviations in odd nuclei are in groups of $I=1$, 11, 23, and 25 and are due to the following shifts:

Non-existent stable nuclei expected by the classification		Actually existing stable nuclei	
Species	I	Species	I
$_{18}A^{39}$	3	$_{19}K^{39}$	1
$_{42}Ma^{97}$	11	$_{42}Mo^{97}$	13
$_{58}Ce^{139}$	23	$_{57}La^{139}$	25
$_{57}La^{137}$	23	$_{56}Ba^{137}$	25
$_{61}Il^{145}$	23	$_{60}Nd^{145}$	25

The position of $_{57}La^{139}$ remains unique in the classification. This odd-even nucleus is located in the midst of a group of the even-odd series. Three of four odd isobars could not be placed in the classification.

D2. Classification of Stable Nuclei by Means of Particles of Mass Number Three and Four. M. H. KURBATOV AND J. D. KURBATOV, *The Ohio State University.*—The requirements imposed in the classification are: (1) that the difference between isotopic numbers of groups of nuclei having common characteristics remain constant and (2) that the mass number of the last nucleus in a group be no higher than that of the first of the following group. The odd-even and even-odd series of nuclei form 22 groups which satisfy these requirements. With the even-even unequal series the conditions are fulfilled by the division

of its 22 groups into four periods: P_2, $I=8a+2$, $A=4b+18$: P_6, $I=8a'+6$, $A=4b'+46$: P_4, $I=8a+4$, $A=4b''+36$: P_8, $I=8a'+8$, $A=4b'''+48$: where $a=0, 1 \cdots 5$; $a'=0, 1 \cdots 4$; $b=0, 1 \cdots 47$; $b'=0, 1 \cdots 38$; $b''=0, 1 \cdots 43$; $b'''=0, 1 \cdots 39$. $\Delta I=8$ is constant and the periods 2 and 6 and 4 and 8, respectively are isobaric. The nuclei of a given sequence are built up by the addition of the group $(2p2n)$. The use of the particles $(p2n)$ and $(n2p)$ results in the continuity of groups of even-odd and odd-even nuclei. A group of even-odd nuclei always precedes one of odd-even nuclei having the same number of particles of mass-number three. The isotopic number of even-odd nuclei, therefore, is two units lower than that of odd-even nuclei in the same sequence. A periodicity of nuclei with common characteristics is observed in the appearance of odd sequences alternating with consecutive periods of even nuclei.

D3. Radioactive Silver. L. K. HURST AND M. L. POOL, *The Ohio State University.*—In the continuance of the study of the radioactive isotopes of silver, variations from former results* were observed. Bombardments of silver with high energy deuterons have given an extremely long silver period of the order of 225 days. Results have been obtained to support the postulation of K-electron capture. X-rays of 0.6A which are close to the K-α x-rays of Pd and a gamma-ray of 1.0 Mev which could be expected from the excited Pd have been observed. Low intensity electrons of 0.5 Mev were also obtained. During this study neutrons which are produced from deuteron bombardment of silver were observed to be energetic enough to produce the n, $2n$ reaction leading to the 24.5-minute Ag^{106} isotope. In consequence of this observation the production of the Ag^{106} isotope by the d, H^3 or d, $p2n$ reaction* must be seriously questioned.

* R. S. Krishnan, Proc. Camb. Phil. Soc. **36**, 500 (1940).

D4. Transmutation of Titanium. CARL T. HIBDON, M. L. POOL, AND J. D. KURBATOV, *The Ohio State University.*—A study of the 16-day period of V^{48} produced by activation of titanium with deuterons has led to a re-evaluation of the energies of the positrons and gamma-rays. The positron upper limit has been found to be 0.58 Mev. Lead absorption measurements indicate a gamma-ray of 1.50 Mev. The probability of V^{48} decaying by K-electron capture to that of positron emission is approximately 18 to 1. The scandium fraction from titanium bombarded with deuterons indicates that the (d, α) reaction is unusually strong. The isomers of Sc^{44} and the isotopes Sc^{46}, Sc^{47}, and Sc^{48} were produced. It has been found that the yield of the 85-day period of Sc^{46} from the Ti^{49} (d, α) reaction is greater than from the Sc^{45} (d, p) reaction. Two new reactions, Ti^{49} (d, α) and Ti^{51} (d, α) are established. The previously reported 72-day period of Ti^{51} was looked for but has not been produced in observable quantities. Alpha-particle bombardments of titanium free of calcium have failed to produce the 3.7-hour period of V^{50}.

D5. The Regularities in Energy Levels of Light Nuclei. W. Y. CHANG, *Princeton University.*—It is found, from the energy levels of about fifty nuclei, that in each of the four series, $4n$, $4n+2$, $4n\pm1$, the nuclei with the same value of the isotopic number $N-Z$ have similar level systems, and that the general distribution of the levels reveals a strong dependence of the level density on the values of $N-Z$. These two points have also been discussed from the standpoint of the "alpha-particle model." In each series the levels of the nuclei having the same value of $N-Z$ can be well expressed by the following formula: $E=as-b/s$, where s is an integer, and a and b are two constants different for different series and $N-Z$. It is found possible to interpret the first term as the contribution of the nuclear particles as if they were not interacting with one another, and the second term as the correction for the interactions. The results stated above are for the levels below dissociation energy. The data for those above dissociation energy is insufficient to make any correlation. However, one point is noted: In a given group of nuclei (i.e., of the same $N-Z$) the energies of the level systems seem to decrease with increasing mass number as would be expected generally from theoretical consideration.

D6. Excitation Functions Obtained by Bombardment of Sodium Bromide with 14-Mev Deuterons. E. T. CLARKE AND J. W. IRVINE, JR., *Massachusetts Institute of Technology.*—Excitation functions for production of the radioactive isotopes Na^{24} (14.8 h), Br^{82} (34 h), and Kr (34 h) were obtained by bombardment of NaBr films obtained by evaporation in high vacuum onto aluminum foil. Deuteron energy determinations were made by measurement of range in aluminum, using the relationship given by Livingston and Bethe.[1] The three activities were separated by solution of each foil in water to liberate the krypton, and precipitation of the bromine as AgBr, leaving the radio-sodium in solution. The activities of each fraction were measured on a calibrated gamma-ray counter, which yielded three excitation curves and the absolute disintegration rates for the Na^{24} and the Br^{82} whose disintegration schemes are known. The reaction $Br^{81}(d, p)Br^{82}$ exhibits an excitation function which begins at about 3 Mev, rises to a maximum absolute cross section of 3.8×10^{-25} cm^2 at 8.5 Mev, and decreases with further increase in energy. The excitation of the reaction $Na^{23}(d, p)Na^{24}$ shows the same shape but begins at about 1 Mev and reaches its maximum value of 4.7×10^{-25} cm^2 at 6 Mev. The reaction $Br(d, 2n)Kr$ shows a definite threshold at 5.3 Mev and rises almost linearly with increase in deuteron energy.

[1] M. S. Livingston and H. A. Bethe, Rev. Mod. Phys. **9**, 261 (1937).

D7. The Variation of the γ-Ray Activity of Radioactive Minerals with Particle Size. F. MORGAN, *Gulf Research and Development Company.*—In oil well logging, carnotite or other radioactive material is frequently added to cement or mud in order to determine subsequently the location of the mixture by γ-ray counters or equivalent devices. To permit a quantitative interpretation of the resulting γ-ray logs, it is necessary to know the strength of the γ-ray source. This information also permits a choice of the optimum quantity of the radioactive tracer to be added to the cement or mud. The strengths of a variety of radio-

active minerals, including a number of carnotites, were accordingly measured. As was expected from previous field observations, the results show large differences in activity. For example, one carnotite sample was found to have at least six times the strength of another of approximately the same cost. For the carnotites tested, the activity was found to be a function of particle size of the mineral. In most cases the activity was a minimum at an intermediate particle size, but for all the samples the finest particles showed by far the greatest activity. Samples of gummite and uraninite gave a more uniform distribution of activity with particle size. These differences can be correlated with the geological origin of the minerals involved.

D8. Charge Distribution around Protons. J. M. BLATT, *Cornell University.*—The calculations of Fröhlich, Heitler, and Kahn[1] for the deviation from the Coulomb law for a proton due to mesons are reexamined and extended to the scalar and pseudoscalar meson theory. It is sufficient to calculate the charge density around the nucleon. The potential energy $U(r)$ for a test particle is then obtained as the solution of Laplace's equation, $\Delta V = 4\pi\epsilon\rho$. A perturbation calculation is used and only the terms proportional to the square of the coupling constant are considered. It is found that in all standard theories (scalar, pseudoscalar, vector) the total charge diverges with some negative power of r. Some physical meaning may be attributed to the charge density in a distance larger than the Compton wave-length of the proton. The same problem was investigated using the recent theory of Dirac[2] which involves negative energy states of the mesons. It turns out that the total charge is exactly zero for all types of meson theories if the recoil of the nucleon is neglected. It has a finite value when the recoil is taken into account.

[1] Fröhlich, Heitler, and Kahn, Proc. Roy. Soc. **A171**, 269 (1939).
[2] P. A. M. Dirac, Proc. Roy. Soc. **A180**, 1 (1942); W. Pauli, Rev. Mod. Phys. **15**, 175 (1943).

SATURDAY AFTERNOON AT 2:00

Lecture Hall, Mellon Institute

Inaugural Programme of the Division of Electron and Ion Optics

Invited Paper

The Thickness of Electron Microscopic Objects. ROBLEY C. WILLIAMS AND RALPH W. G. WYCKOFF, *Universtiy of Michigan.* (20 minutes.)

Contributed Papers

E1. Paths of Electrons and Ions in Non-Uniform Magnetic Fields. N. D. COGGESHALL AND M. MUSKAT, *Gulf Research and Development Company.*—The integration of the Lorentz force equations to give electron or ion paths has been reduced to simple quadratures for systems in which the electric field is zero and the magnetic field is a function of one Cartesian or cylindrical coordinate. For several interesting types of magnetic field variation the quadrature can be carried through analytically, and even for complicated magnetic fields, or such as are known only empirically, the numerical integration can be effected without difficulty. From general considerations of the functions involved, it is possible to determine the extension and periodicity of the orbits for any set of initial conditions. The representation used is also convenient for obtaining information regarding the dispersion and focusing characteristics of the trajectories, such as may be used for instrument design. Illustrations of such results will be presented, including the manner in which the nature of the orbits varies with changing initial conditions.

E2. Energy Distribution of Electrons Within Dense Electron Beams. C. J. CALBICK, *Bell Telephone Laboratories.*—An electron beam injected into an enclosure having equipotential walls sets up a non-uniform potential distribution within the enclosure because of space charge.[1] The non-uniformity increases with beam current until an unstable condition is reached when current falls rapidly and a virtual cathode forms. Calculations are presented for beams and enclosures of two- and three-dimensional symmetry. In the first case, the maximum possible beam current is $i = 9.4\times10^{-6}y\Phi^{3/2}$ when the beam, of half-width y, completely fills the enclosed space whose walls are at potential Φ relative to the electron source. When the virtual cathode forms, the maximum current drops to $i = 4.65\times10^{-6}y\Phi^{3/2}$. In the second case, the corresponding values are $i = 3.8\times10^{-5}\Phi^{3/2}$ and $i = 3\times10^{-5}\Phi^{3/2}$ and do not depend on beam radius. If the beam does not fill the enclosure, the maximum currents are reduced, especially in the second case. With dense beams, deflection of an electron by electric or magnetic fields depends on its trajectory within the beam, and thus deflection distortion of an electron "spot" may become serious.

[1] A. V. Haeff, Proc. I.R.E. **27**, 5 (1939).

E3. Limiting Stable Current in Electron Beams in the Presence of Ions. J. R. PIERCE, *Bell Telephone Laboratories.*—If an electron current at a given voltage is injected into the space between two grids, there is a limiting stable value of electron current beyond which a virtual cathode will form. There is a similar limiting current

for electrons restrained by an infinite magnetic field to axial motion through a conducting tube. There are similar limiting stable currents even if the electronic space charge is neutralized by positive ions of infinite mass. Such a limiting current is a constant times the limiting current in the absence of ions. For parallel grids the limiting current density is

$$i_m = 2^{7/2}\pi^2(e/m)^{1/2}\epsilon V_0^{3/2}/x^2.$$

For a conducting tube of infinite length capped by grids the limiting current is

$$I_m = 2^{3/2}(2.4)^2\pi(e/m)^{1/2}\epsilon V_0^{3/2}.$$

E4. Mass Spectrometer with a Small Magnet. R. E. Fox, J. A. Hipple, and T. W. Williams, *Westinghouse Research Laboratories.*—A five-inch radius, 60° type mass spectrometer with a unique magnet design has been constructed. The magnet pole faces are sealed into the analyzer tube by means of a Kovar cylinder to which the glass is sealed, thus establishing the vacuum seals. The magnetic flux is transmitted to the pole faces through the Kovar cylinder from an external source which is either a permanent or an electromagnet. Uniform magnetic fields of about 1500 gauss in a quarter-inch gap have been obtained with an instrument in which the complete analyzer tube plus the magnet weighed less than twenty-five pounds. The design and construction of the magnet allows the pole faces to be accurately aligned to less than 0.001 inch. With a larger external magnet it is possible to obtain stronger fields, since the size of the magnet is not fundamentally limited. Two metal cylinders bolted to the 60° magnet faces act as shields for the ion beam and also serve to mount the ion source and collector. These metal cylinders are so constructed that when bolted to the magnet the ion source and collector slits are automatically aligned with the magnet gap.

E5. The Reversed Cyclotron. Laurence Ellsworth Dodd, *University of California at Los Angeles.*—A procedure based on theory and practicable experimentally would be to operate the cyclotron backward. Such reversal would permit the slowing down to some desired speed, perhaps zero, of an ionic particle having initially a high velocity. The principle is applicable theoretically for the stopping in this manner of a high speed cosmic-ray ion. Whether this is practicable for example in the case of a six-billion-volt cosmic-ray electron appears to be a question of attaining experimentally the ultra-high frequency of reversal of potential that would be necessary.

E6. Portable Demonstration Electron Microscope. Igor Bensen, *General Electric Company.*—A discussion of the design features making possible a compact light-weight instrument completely contained in two suitcase units.

E7. Potential Nuclear Monochromatic Electron Sources. M. L. Pool, *Ohio State University.*—Among the some 300 synthesized radioactive nuclei now available a few have been found which emit electrons in a narrow energy range. Most nuclei, however, emit the well-known continuous beta-ray spectrum. The above-mentioned few special nuclei are identified with internally converted nuclear gamma-rays. It is desirable that the internal conversion coefficient be close to 100 percent. Monochromatic electron energy bands between 50 and 300 Kev may be had originating from certain nuclei with half-lives up to several months. Detail data for the isotopes Pb^{205}, Tl^{202}, Ba^{133}, and Ba^{135} will be presented as well as a summary of the field. Eventual applications of nuclear sources seem probable for certain uses in electron microscopes, electron diffraction, and special radio tubes. (*Invited Paper*—20 minutes.)

E8. Electron Microscope Study of Ferromagnetic Domains. L. Marton, *Stanford University.*—Ferromagnetic domains can be investigated by means of the electron microscope by using a replica technique. Such replicas can be prepared by suspending a ferromagnetic colloid in the solution of a plastic to be cast on the polished surface of a ferromagnetic material. After solidifying the plastic on the surface of the magnetized sample it can be stripped in the same way as any other metallographic replica. Preliminary experiments show that gelatine is a good suspending medium; however, it offers difficulties in stripping. The preparation of similar colloids in the usual plastics of replica technique offer some difficulties also. A variant of the method consists in placing a very thin collodion film in contact with the sample and placing a droplet of the ferromagnetic colloid on the film. After evaporation of the solvent the film is lifted and placed in the microscope. Patterns obtained on different materials and at different degrees of magnetization are shown.

E9. Studies of Purified Preparations of the MV Strain of Poliomyelitis Virus by Means of the Electron Microscope. H. S. Loring, C. E. Schwerdt, and L. Marton, *Stanford University.*—Several highly purified preparations of the MV strain of poliomyelitis virus have been examined in the Stanford electron microscope. The samples were prepared by the procedures previously described[1] with the exception that in some cases the extracts were allowed to stand in the refrigerator for several weeks before the solution was ultracentrifuged. In biological tests for activity with some preparations 100 percent of the animals developed poliomyelitis when injected at concentrations of 5×10^{-10} g of nitrogen. The micrographs show the presence of a relatively homogeneous material. The majority of the particles appear spherical or nearly spherical in shape. They are also considerably less well-defined than the reference particles on the same micrographs. Estimations of the diameters of the presumed virus particles range from 15 to 20 mμ. There is, however, a definite indication of asymmetry ranging from 1 : 2 to 1 : 5 in some of the micrographs. The possible explanation of this asymmetry, as being due to a chain-like aggregation of the smaller particles, must be left open at present. No evidence has been obtained in any of the preparations for the highly asymmetric or thread-like particles reported for the murine strain by Gard and Pedersen.

[1] H. S. Loring and C. E. Schwerdt, J. Exper. Med. 75. 395 (1942).

To Be Read by Title

T1. Note on the Inductive Measurement of Magnetic Field Strength* F. T. ROGERS, JR.,† *The University of Houston.* To be read by title.—Two of the minor corrections[1] to which the standard expression[1] $MI/2AN$ for magnetic field strengths is subject, are listed here in a convenient approximate form. For small effects of twisted leads to the rotating coil, multiply $MI/2AN$ by

$$F_1 = 1 - a/2AN, \tag{1}$$

where a is the small "projected area" of the (equal) "loops" in the leads. For small effects of incorrect orientations of the coil, multiply $MI/2AN$ by

$$F_2 = 2 \sec \phi / [\cos(\theta - \epsilon) + \cos\theta], \tag{2}$$

where ϵ is the small defect of the rotation angle from 180°, ϕ is the small angle between the axis of rotation and the plane (P) perpendicular to the field, and θ is the small angle between the plane of the coil in its initial prerotational position and P.

* Contribution No. 90 from The Division of Sciences of The University of Houston.
† Now with The Lukas-Harold Corporation, Indianapolis.
[1] See F. T. Rogers, Jr., Phys. Rev. 52, 381 (1937) for the definitions of symbols.

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(To be sent to Professor A. G. Worthing, University of Pittsburgh, Pittsburgh, Pennsylvania)

I EXPECT to attend the dinner of the American Physical Society at the Schenley Hotel, Pittsburgh, at half-past six o'clock on Friday evening, April 28, 1944. My party will consist of ____ persons.